REMARKS

Claims 1-13 are in the application and stand rejected. Claims 1, 4, 6, and 8 are amended and new claims 14-16 are added.

Fig. 2 has been amended by providing labels for line(s) **32** referenced on page 10, line 9, thereby obviating the objection.

Applicants point out that the secondary membrane retentate gas is properly identified in Fig. 1 and on page 9, line 19 by reference number "**30**". The specification on page 7, line 30 is therefore amended to correct an obvious error and eliminates another objection to the drawings.

Page 7 at lines 1-5 has also been amended based upon disclosure at page 2, lines 25-27 of priority application Serial No. 60/430,270.

Other defects of form of the specification that were noted in Office Action paragraph 9. have also been corrected.

Claim 1 is amended for conformity with conventional terminology that a membrane described as selective to a first component relative to a second component implies that the first component permeates preferentially relative to the second component. Consistent amendments to claims 8 and 10, and to the specification on page 3, line 7 and page 4, line 20 are also made. These changes should obviate the section 112 rejections. Other references in the application to the selectivity of the membrane to methane, for example on page 3, lines 28-29, are not inconsistent with conventional terminology and should not require amendment in this regard.

Claim 1 has been further amended to recite a limitation that the methane recovery system includes a polishing bed of activated carbon between the pressure swing adsorption unit and the primary gas separation module. Claims 6 and 8 are similarly

amended and further call for the bed of activated carbon to be effective to remove volatile organic compounds in concert with the pressure adsorption units. These limitations are supported by the disclosure on page 7, lines 1-5, as currently amended, page 9, lines 19-20 and Fig. 1.

Claim 4 is amended consistent with disclosure on page 9, lines 30-32 and Fig. 2. This amendment places the "plurality" of pressure swing adsorption units in context with "a pressure swing adsorption unit" referenced at line 3 of claim 1. Claim 6 is amended to provide antecedent basis for "the pressure swing adsorption units" in claims 6 and 7.

Amendments to claims 8 and 10 concerning preferential selectivity of the membranes for carbon dioxide relative methane are believed adequate to overcome the rejections under 35 U.S.C. §112, second paragraph. Similar rejections to dependent claims 2,3,5,9 and 11-13 are also obviated by the above-described amendments.

New claim 14 is based upon disclosure on page 7, lines 1-5 as currently amended.

New claims 15 and 16 are supported by disclosure on page 1, lines 17-18, on page 6, lines 29-30 and on page 9, lines 15 and 29. These passages indicate that the crude feed gas has substantial water concentration, that the pressure swing adsorber unit utilizes adsorbent compositions such as activated alumina and silica gel (that can remove moisture as well as VOC's), and that the product gas processed through the adsorbers has low concentrations of water vapor.

No new matter has been added by the above-described amendments.

Claims 6-11 stand rejected under 35 U.S.C. §102(b) as being anticipated by FR 2836058. FR '058 was published on August 22, 2003. (See bibliographic item "43" on the title page.) The instant application claims priority of US provisional application Serial No. 60/437,268 filed December 31, 2002. That application contains very much the same disclosure of the present application. Based on priority, Applicants submit that the French publication is not properly prior art to this application and accordingly request that this rejection be withdrawn.

Claims 6 and 7 stand rejected under 35 U.S.C. §102(b) as being anticipated by Doshi (US 4,645,516). This rejection is respectfully traversed.

Doshi discloses a gas purification process that improves upon permeable membrane separation. Doshi teaches that pressure swing adsorption units can be inserted upstream of the membrane separators such that selected components of the membrane feed composition are removed to the extent that they may be harmful to the downstream membranes. Doshi teaches that this process can apply, among others, to feed gas containing natural gas (methane) to be separated from carbon dioxide and hydrogen sulfide.

The present invention claims a system and process in which the crude gas feed mixture from a waste landfill is treated upstream of membrane separators by a subsystem of pressure swing adsorbers in combination with a polishing bed of activated carbon. The pressure swing adsorbers strip a large fraction of the volatile organic compounds from the crude gas mixture much as disclosed by Doshi. However, the addition of an activated carbon bed between the pressure swing adsorbers and the primary

membrane separator enables this system to clean the intermediate gas more effectively than Doshi. That is, the pressure swing adsorbers do not have to operate at as extreme conditions or be regenerated as frequently as those in Doshi to achieve the same low level of volatile organics. This is because the small amount of organic compounds that passes through the less rigorously operated adsorbers can be captured by the activated carbon bed to reach the same low concentration of organic compounds fed to the membrane that Doshi's system would provide. Viewed another way, the adsorbers in combination with the activated carbon bed of this invention can provide a feed to the membranes that is more free of organic compounds than would be provided by Doshi with similarly sized and operated adsorbers but without a follow-up activated carbon bed. Providing a more organic-free feed preserves the ability of the downstream membrane separators to function at high performance levels longer than would a more contaminated feed.

Doshi is thus different from the claimed invention by not disclosing an activated carbon bed between the pressure swing adsorbers and the membranes. Moreover, Doshi teaches that the components harmful to the membrane (i.e., the volatile organic compounds in this case) need not be removed essentially completely but only sufficiently to prevent "undue damage" to the membranes. See col. 7, lines 59-68. In this sense it teaches away from the novel system and process in which the combination of pressure swing adsorbers and activated carbon bed is able to remove substantially all of the volatile organic compounds that would otherwise feed to the membrane (page 9, lines 19-20).

Applicants further maintain that adding an activated carbon bed as claimed would not have been an obvious variation of

Doshi. The references teaches that pressure swing adsorption should be self-sufficient to remove an adequate amount of membrane-harmful contaminants. Thus there would be no motivation to supplement pressure swing adsorbers with an activated carbon bed and thereby reduce the contaminants concentration more than minimally necessary.

Applicants have found that the ability of pressure swing adsorbers to remove substantial amounts of the total volatile organic compound load is indeed what makes practical the addition of a polishing activated carbon bed. An activated carbon bed without pressure swing adsorbers in theory could strip volatile organics from the feed. However, such a bed, being non-regenerating, would require replacement at such high frequency as to be practically impossible to implement in the recovery of landfill gas. In this invention, however, the non-regenerating carbon bed only assumes a small portion of the total volatile organic stripping load. It can therefore remain in service without replacement for a relatively long time. That fact makes feasible a system having a carbon bed combined with swing adsorbers.

The novel methane recovery process (e.g., claim 14) also calls for removing siloxane compounds in the pressure swing adsorbers. Silicone compounds are typically present in waste landfill gas. They are undesirable in methane recovery for fuel because during combustion of recovered methane they convert to a hard, glass-like form that fouls and is difficult to remove from combustion equipment. Doshi only teaches to use pressure swing adsorbers to remove components of feed that are harmful to the membranes of the downstream separators. Siloxanes are not harmful to the membranes hence Doshi does not teach or suggest a

process to remove siloxanes. Applicants urge that the process of claim 14 is also patentable for this reason.

Claims 1-13 stand rejected under 35 U.S.C. §102(b) as being anticipated by Borray et al. (US 5,727,903) "Borray". This rejection is respectfully traversed on the following grounds.

Borray discloses a process and apparatus for purifying and compressing raw landfill gas to produce vehicle grade compressed gas for motor vehicle fuel. A primary difference between Borray and this invention is that the former does not disclose the inclusion of an activated carbon bed between the swing adsorber unit operation and the membrane separation operation. This difference was addressed above in Applicants' arguments relating to Doshi. Thus, Borray also does not teach or suggest the use of a supplemental activated carbon bed coupled with swing adsorbers.

Another difference is that Borray apparently teaches a thermal swing adsorption ("TSA") process for removing volatile organic compounds. During removal of organics, the adsorbers appear to operate at about 140°F at which the feed stream enters to maintain water content in vapor form (col. 6, lines 42-46). The accumulated organics in the "guard beds" is driven off by heating the membrane system permeate gas to 400°F in an in-line heater (col. 7, lines 23-26). Thus the temperature of the adsorbing guard beds is cycled between about 140°F and 400°F. In contrast, the present claims are limited to pressure swing adsorption ("PSA"). As explained on page 11, lines 7-17, the PSA process typically operates at between 200 psig (adsorbing) and 5 psig (regenerating) and always generally isothermally at about 45°C (113°F).

Yet another difference from Borray is that the novel system utilizes adsorbent particles of activated alumina and silica gel (claim 16). Borray only discloses guard bed adsorbers using activated carbon. The novel process thus in one aspect includes removing water from the gas feed in the pressure swing adsorbers (claim 15). Activated carbon cannot adsorb water, hence, Borray does not anticipate this feature of the invention.

As mentioned, Borray teaches that the adsorber feed gas must be heated to at least 140°F to maintain any water present in vapor form. In thermal swing adsorption generally, the ability of the adsorber to strip adsorbate components from the feed mixture depends upon the difference between the adsorption (low) temperature and the desorption (high) temperature of the operating cycle. The higher the low temperature, the smaller the thermal "swing", other conditions being equal. A smaller swing implies a less effective separation than otherwise achievable. Consequently, requiring the feed be pre-heated to about 140°F according to Borray imposes a limitation on the effectiveness of thermal swing adsorption. Applicants submit that this artifact of Borray suggests away from a TSA-based process.

Borray teaches that the guard bed system removes volatile organic compounds and compressor lubrication oil to protect the membranes. This invention claims (claim 14) that the pressure swing adsorption units completely remove siloxane contamination of the raw landfill gas. As with Doshi above, Borray makes no mention of stripping siloxanes from landfill gas in the adsorbers, or elsewhere. This aspect of the invention is not anticipated nor would it have been obvious over Borray.

In sum, the present invention should be found patentable over Borray because the reference does not disclose any of (a) a

combination of a swing adsorber and an activated carbon bed to remove volatile organic compounds, (b) pressure swing adsorption to remove the volatile organic compounds, (c) utilizing activated alumina or silica gel adsorbents in the swing adsorbers, (d) removal in the swing adsorber operation of water from the feed gas, or (e) removal from the landfill gas of siloxanes by the swing adsorbers.

For the above recited reasons, Applicants respectfully submit that the claims pending in the application are novel and non-obvious over the prior art and asks that allowance be entered in the next official action.

Respectfully submitted,

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IN THE DRAWINGS:

Amend Fig. 2 as shown in the appended Replacement Sheet.

The only changes to drawing Fig. 2 are two additions of reference number **32** and accompanying leader lines. The drawing sheet caption information has also been updated.